CLAIMS

1. A free flow electrophoresis microchip, comprising:
a separation chamber in which charged components are in use separated;
a plurality of separation medium inlet channels having outlets fluidly connected to one, inlet side of the separation chamber through which flows of a separation medium are in use introduced into the separation chamber such as to develop a laminar flow having a flow direction through the separation chamber;
a sample inlet channel having an outlet fluidly connected to the inlet side of the separation chamber through which a flow of a sample containing charged components is in use introduced into the separation chamber;
a plurality of outlet channels having inlets fluidly connected to another, outlet side of the separation chamber opposite the inlet side thereof; and
a magnetic field unit for providing a magnetic field substantially orthogonal to the flow direction of the separation medium;
whereby charged components introduced into the separation chamber are deflected laterally across the separation chamber in dependence upon the charge of the charged components.

2. The microchip of claim 1, wherein the outlets of the separation medium inlet channels are disposed in spaced relation along the inlet side of the separation chamber.

3. The microchip of claim 1 or 2, wherein the outlet of the sample inlet channel is disposed in a central region of the inlet side of the separation chamber.

4. The microchip of claim 1 or 2, wherein the outlet of the sample inlet channel is disposed in an end region of the inlet side of the separation chamber.

5. The microchip of any of claims 1 to 4, wherein the outlets of the sample inlet channel and the separation medium inlet channels face in the same direction.

6. The microchip of any of claims 1 to 5, wherein the separation medium inlet channels are commonly fluidly connected.

7. The microchip of any of claims 1 to 5, wherein groups of ones of the separation medium inlet channels are commonly fluidly connected.

8. The microchip of any of claims 1 to 5, wherein the separation medium inlet channels are separately fluidly connected.

9. The microchip of any of claims 1 to 8, wherein the outlets of the sample inlet channel and the separation medium inlet channels are disposed in opposed relation to the inlets of the outlet channels.

10. The microchip of any of claims 1 to 9, wherein the inlets of the outlet channels have a depth at least as great as that of the separation chamber.

11. The microchip of any of claims 1 to 10, wherein the inlets of the outlet channels are disposed in spaced relation along the outlet side of the separation chamber.

12. The microchip of claim 11, wherein the inlets of the outlet channels are equi-spaced.

13. The microchip of any of claims 1 to 12, wherein the separation chamber comprises a planar chamber having a planar region.

14. The microchip of claim 13, wherein the magnetic field is directed substantially orthogonally to the planar region of the separation chamber.

15. The microchip of claim 13 or 14, wherein the separation chamber has a depth of from about 5 μm to about 50 μm.

16. The microchip of any of claims 1 to 15, wherein the magnetic field unit comprises at least one magnet.

17. The microchip of claim 16, wherein the at least one magnet comprises a layer of magnetic material.

18. The microchip of claim 17, wherein the magnetic material comprises a Ni-Fe permalloy.

19. The microchip of any of claims 1 to 18, further comprising:
first and second electrode units disposed at respective ones of other, lateral sides of the separation chamber.

20. The microchip of claim 19, wherein the electrode units each comprise an electrolyte reservoir disposed adjacent the respective lateral side of the separation chamber for containing a volume of an electrolyte medium, and a plurality of connection channels fluidly connecting the electrolyte reservoir to the respective lateral side of the separation chamber.

21. The microchip of claim 20, wherein each electrolyte reservoir has substantially the same length as the separation chamber.

22. The microchip of claim 20 or 21, wherein the connection channels are disposed in spaced relation along the respective lateral sides of the separation chamber.

23. The microchip of claim 22, wherein the connection channels are equi-spaced.

24. The microchip of any of claims 20 to 23, wherein the connection channels have a width of from about 1 μm to about 5 μm.

25. The microchip of any of claims 20 to 24, wherein the electrode units each further comprise an electrode element disposed in the respective electrolyte reservoir.

26. A free flow electrophoresis separation system, comprising:
the free flow electrophoresis microchip of any of claims 19 to 25; and

a high-voltage supply for applying an electric field between the electrode units and across the separation chamber in a direction substantially orthogonal to the magnetic field;
whereby a magnetohydrodynamic flow of sample and separation medium is induced through the separation chamber.

27. A free flow electrophoresis separation system, comprising:
the free flow electrophoresis microchip of any of claims 1 to 25; and
a supply unit for supplying flows of sample and separation medium through the respective ones of the sample inlet channel and the separation medium inlet channels and into the separation chamber;
whereby an electric field is induced across the separation chamber in a direction substantially orthogonal to the flow direction.

28. The system of claim 27, wherein the supply unit comprises a first transfer unit fluidly connected to the sample inlet channel for delivering a flow of sample through the sample inlet channel and into the separation chamber, and at least one second transfer unit fluidly connected to the separation medium inlet channels for delivering flows of separation medium through the separation medium inlet channels and into the separation chamber.

29. The system of claim 28, wherein at least one of the first transfer unit and the at least one second transfer unit are operable to control flow rates of the sample and separation medium flows to the separation chamber.

30. The system of claim 28 or 29, wherein the at least one second transfer unit comprises a plurality of second transfer units fluidly connected to respective ones of the separation medium inlet channels.

31. The system of claim 30, wherein the plurality of second transfer units are fluidly connected to groups of ones of the separation medium inlet channels.

32. The system of claim 30, wherein the plurality of second transfer units are fluidly connected to separate ones of the separation medium inlet channels.

33. The system of any of claims 28 to 32, wherein each transfer unit comprises a delivery pump.

34. The system of any of claims 26 to 33, further comprising:
at least one collection unit fluidly connected to at least one of the outlet channels for collection of at least one separated component.

35. The system of claim 34, comprising:
a plurality of collection units fluidly connected to respective ones of the outlet channels for collection of a plurality of separated components.

36. The system of any of claims 26 to 35, further comprising:
a detection unit for detecting migration of at least one separated component through at least one of the outlet channels.

37. The system of claim 36, wherein the detection unit is configured to detect migration of separated components through a plurality of ones of the outlet channels.

38. The system of claim 37, wherein the detection unit is configured to detect migration of separated components through each of the outlet channels.

39. A free flow electrophoresis method of separating charged components, the method comprising the steps of:
providing a free flow electrophoresis microchip, comprising: a separation chamber in which charged components are separated; a plurality of separation medium inlet channels having outlets fluidly connected to one, inlet side of the separation chamber; a sample inlet channel having an outlet fluidly connected to the inlet side of the separation chamber; a plurality of outlet channels having inlets fluidly connected to another, outlet side of the separation chamber opposite

the inlet side thereof; a magnetic field unit for providing a magnetic field in a direction substantially orthogonal to the flow direction of the separation medium; and first and second electrode units disposed at respective ones of other, lateral sides of the separation chamber; and

applying a potential between the electrode units so as to generate an electric field across the separation chamber in a direction substantially orthogonal to the magnetic field direction, wherein the electric field acts together with the magnetic field to induce a magnetohydrodynamic flow of sample and separation medium through the separation chamber, and deflect the charged components laterally across the separation chamber in dependence upon the charge of the charged components.

40. The method of claim 39, wherein the outlets of the separation medium inlet channels are disposed in spaced relation along the inlet side of the separation chamber.

41. The method of claim 39 or 40, wherein the outlet of the sample inlet channel is disposed in a central region of the inlet side of the separation chamber.

42. The method of claim 39 or 40, wherein the outlet of the sample inlet channel is disposed in an end region of the inlet side of the separation chamber.

43. The method of any of claims 39 to 42, wherein the outlets of the sample inlet channel and the separation medium inlet channels face in the same direction.

44. The method of any of claims 39 to 43, further comprising the step of:
commonly introducing separation medium through the separation medium inlet channels.

45. The method of any of claims 39 to 43, further comprising the step of:
introducing different separation media through respective groups of ones of the separation medium inlet channels.

46. The method of any of claims 39 to 43, further comprising the step of: introducing different separation media through respective ones of the separation medium inlet channels.

47. The method of any of claims 39 to 46, wherein the outlets of the sample inlet channel and the separation medium inlet channels are disposed in opposed relation to the inlets of the outlet channels.

48. The method of any of claims 39 to 47, wherein the inlets of the outlet channels have a depth at least as great as that of the separation chamber.

49. The method of any of claims 39 to 48, wherein the inlets of the outlet channels are disposed in spaced relation along the outlet side of the separation chamber.

50. The method of claim 49, wherein the inlets of the outlet channels are equi-spaced.

51. The method of any of claims 39 to 50, wherein the separation chamber comprises a planar chamber having a planar region.

52. The method of claim 51, wherein the magnetic field direction is in a direction substantially orthogonal to the planar region of the separation chamber.

53. The method of claim 51 or 52, wherein the separation chamber has a depth of from about 5 μm to about 50 μm.

54. The method of any of claims 39 to 53, wherein the magnetic field unit comprises at least one magnet.

55. The method of claim 54, wherein the at least one magnet comprises a layer of magnetic material.

56. The method of claim 55, wherein the magnetic material comprises a Ni-Fe permalloy.

57. The method of any of claims 39 to 56, wherein the electrode units each comprise an electrolyte reservoir disposed adjacent the respective lateral side of the separation chamber for containing a volume of an electrolyte medium, and a plurality of connection channels fluidly connecting the electrolyte reservoir to the respective lateral side of the separation chamber.

58. The method of claim 57, wherein each electrolyte reservoir has substantially the same length as the separation chamber.

59. The method of claim 57 or 58, wherein the connection channels are disposed in spaced relation along the respective lateral sides of the separation chamber.

60. The method of claim 59, wherein the connection channels are equi-spaced.

61. The method of any of claims 57 to 60, wherein the connection channels have a width of from about 1 μm to about 5 μm.

62. The method of any of claims 57 to 61, wherein the electrode units each further comprise an electrode element disposed in the respective electrolyte reservoir.

63. The method of any of claims 39 to 62, further comprising the step of: collecting at least one separated component from at least one of the outlet channels.

64. The method of claim 63, wherein the step of collecting at least one separated component comprises the step of: collecting separated components from respective ones of the outlet channels.

65. The method of any of claims 39 to 64, further comprising the step of:

detecting migration of at least one separated component through at least one of the outlet channels.

66. The method of claim 65, wherein the step of detecting migration of at least one separated component comprises the step of:
detecting migration of separated components through a plurality of ones of the outlet channels.

67. The method of claim 66, wherein the step of detecting migration of at least one separated component comprises the step of:
detecting migration of separated components through each of the outlet channels.

68. A free flow electrophoresis method of separating charged components, the method comprising the steps of:
providing a free flow electrophoresis microchip, comprising: a separation chamber in which charged components are separated; a plurality of separation medium inlet channels having outlets fluidly connected to one, inlet side of the separation chamber; a sample inlet channel having an outlet fluidly connected to the inlet side of the separation chamber; a plurality of outlet channels having inlets fluidly connected to another, outlet side of the separation chamber opposite the inlet side thereof; and a magnetic field unit for providing a magnetic field in a direction substantially orthogonal to the flow direction of the separation medium; and
supplying flows of sample and separation medium through the respective ones of the sample inlet channel and the separation medium inlet channels into and through the separation chamber, wherein the flow of separation medium acts together with the magnetic field to induce an electric field across the separation chamber in a direction substantially orthogonal to the flow direction, which electric field acts to deflect the charged components laterally across the separation chamber in dependence upon the charge of the charged components.

69. The method of claim 68, wherein the outlets of the separation medium inlet channels are disposed in spaced relation along the inlet side of the separation chamber.

70. The method of claim 68 or 69, wherein the outlet of the sample inlet channel is disposed in a central region of the inlet side of the separation chamber.

71. The method of claim 68 or 69, wherein the outlet of the sample inlet channel is disposed in an end region of the inlet side of the separation chamber.

72. The method of any of claims 68 to 71, wherein the outlets of the sample inlet channel and the separation medium inlet channels face in the same direction.

73. The method of any of claims 68 to 72, wherein the step of supplying sample and separation medium includes the step of:
commonly supplying separation medium through the separation medium inlet channels.

74. The method of any of claims 68 to 72, wherein the step of supplying sample and separation medium includes the step of:
supplying different separation media through respective groups of ones of the separation medium inlet channels.

75. The method of any of claims 68 to 72, wherein the step of supplying sample and separation medium includes the step of:
supplying different separation media through respective ones of the separation medium inlet channels.

76. The method of any of claims 68 to 75, wherein the step of supplying sample and separation medium comprises the step of:
delivering sample and separation medium flows through the respective ones of the sample inlet channel and the separation medium inlet channels and into the separation chamber.

77. The method of any of claims 68 to 76, wherein flow rates of the sample and separation medium flows are regulated to control the lateral deflection of the charged components.

78. The method of any of claims 68 to 77, wherein the outlets of the sample inlet channel and the separation medium inlet channels are disposed in opposed relation to the inlets of the outlet channels.

79. The method of any of claims 68 to 78, wherein the inlets of the outlet channels have a depth at least as great as that of the separation chamber.

80. The method of any of claims 68 to 79, wherein the inlets of the outlet channels are disposed in spaced relation along the outlet side of the separation chamber.

81. The method of claim 80, wherein the inlets of the outlet channels are equi-spaced.

82. The method of any of claims 68 to 81, wherein the separation chamber comprises a planar chamber having a planar region.

83. The method of claim 82, wherein the magnetic field direction is in a direction substantially orthogonal to the planar region of the separation chamber.

84. The method of claim 82 or 83, wherein the separation chamber has a depth of from about 5 μm to about 50 μm.

85. The method of any of claims 68 to 84, wherein the magnetic field unit comprises at least one magnet.

86. The method of claim 85, wherein the at least one magnet comprises a layer of magnetic material.

87. The method of claim 86, wherein the magnetic material comprises a Ni-Fe permalloy.

88. The method of any of claims 68 to 87, wherein the microchip further comprises: first and second electrode units disposed at respective ones of other, lateral sides of the separation chamber.

89. The method of claim 88, wherein the electrode units each comprise an electrolyte reservoir disposed adjacent the respective lateral side of the separation chamber for containing a volume of an electrolyte medium, and a plurality of connection channels fluidly connecting the electrolyte reservoir to the respective lateral side of the separation chamber.

90. The method of claim 89, wherein each electrolyte reservoir has substantially the same length as the separation chamber.

91. The method of claim 89 or 90, wherein the connection channels are disposed in spaced relation along the respective lateral sides of the separation chamber.

92. The method of claim 91, wherein the connection channels are equi-spaced.

93. The method of any of claims 89 to 92, wherein the connection channels have a width of from about 1 μm to about 5 μm.

94. The method of any of claims 89 to 93, wherein the electrode units each further comprise an electrode element disposed in the respective electrolyte reservoir.

95. The method of any of claims 68 to 94, further comprising the step of: collecting at least one separated component from at least one of the outlet channels.

96. The method of claim 95, wherein the step of collecting at least one separated component comprises the step of:

collecting separated components from respective ones of the outlet channels.

97. The method of any of claims 68 to 96, further comprising the step of: detecting migration of at least one separated component through at least one of the outlet channels.

98. The method of claim 97, wherein the step of detecting migration of at least one separated component comprises the step of: detecting migration of separated components through a plurality of ones of the outlet channels.

99. The method of claim 98, wherein the step of detecting migration of at least one separated component comprises the step of: detecting migration of separated components through each of the outlet channels.